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(54) Abstract Title
Remotely controlled robotic toy

(57) Apparatus 1 for recreational and other uses, comprises a remotely controlled mechanically legged model robot 2 and the remote-control means 3 for operating the device 2. The remotely-controlled legged model robot 2 comprises a body section 4 and first, second, third and fourth leg sections 5, 6, 7, 8, which in turn comprise thigh portions 9, hip joints 10, knee joints 12 and shin/foot portions 11. Each leg section is controlled by an individual control means which preferably comprises a joystick configured in a shape similar to the leg section. On movement of the joystick signals are transduced to the leg section to produce similar movements to those effected on the joystick. Movements are compensated for by negative feedback control.

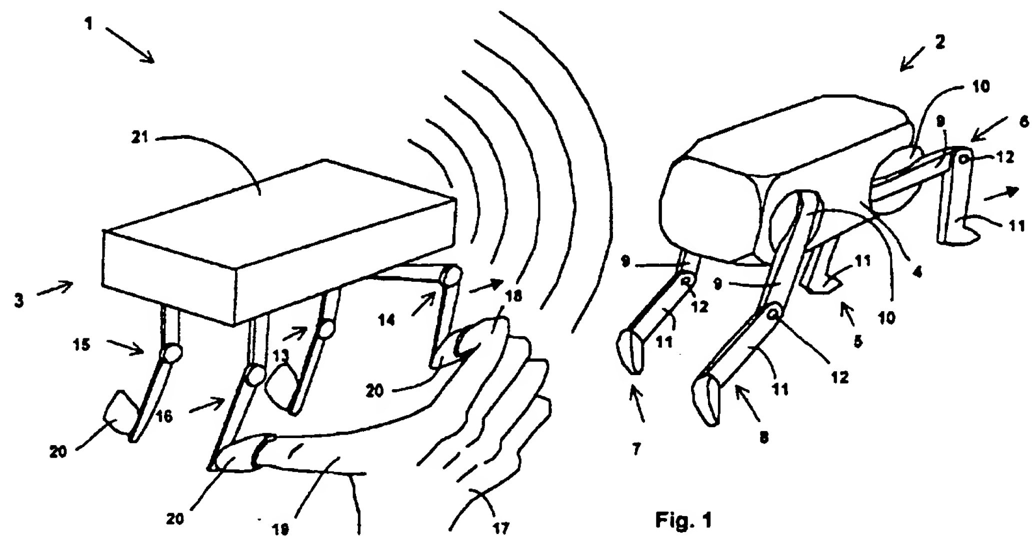

Fig. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy. The claims were filed later than the filing date but within the period prescribed by Rule 25(1) of the Patents Rules 1995. This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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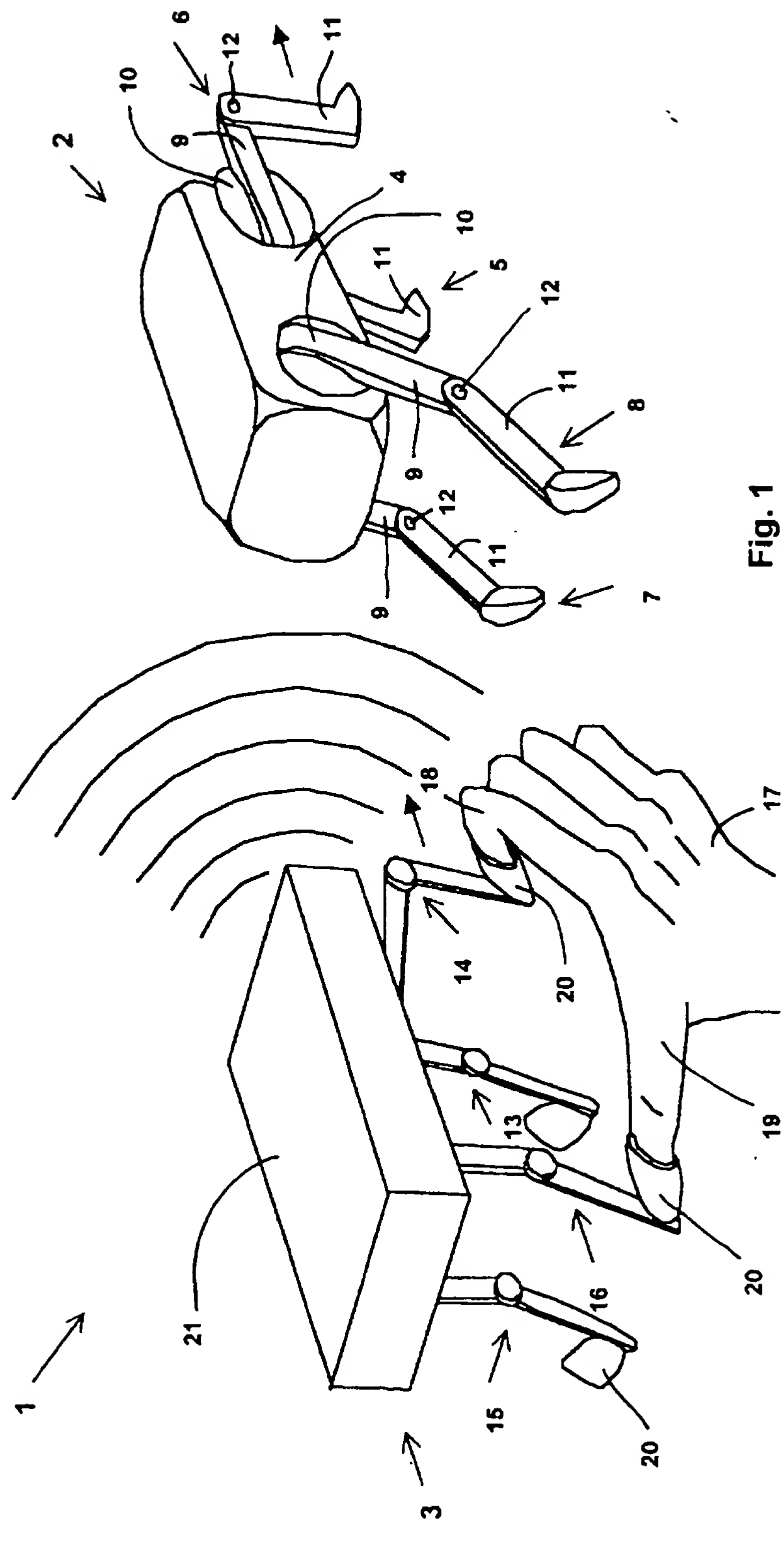

Fig. 1

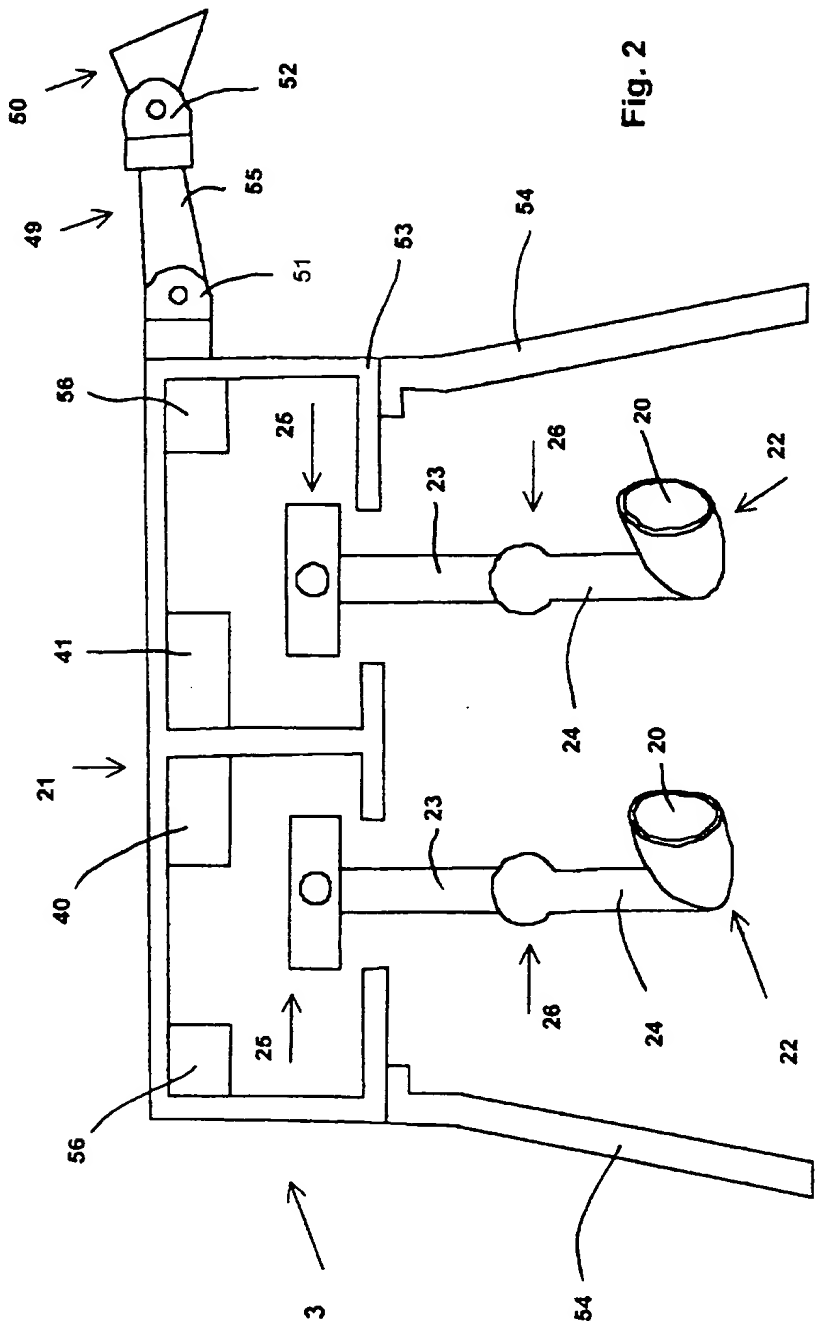

Fig. 2

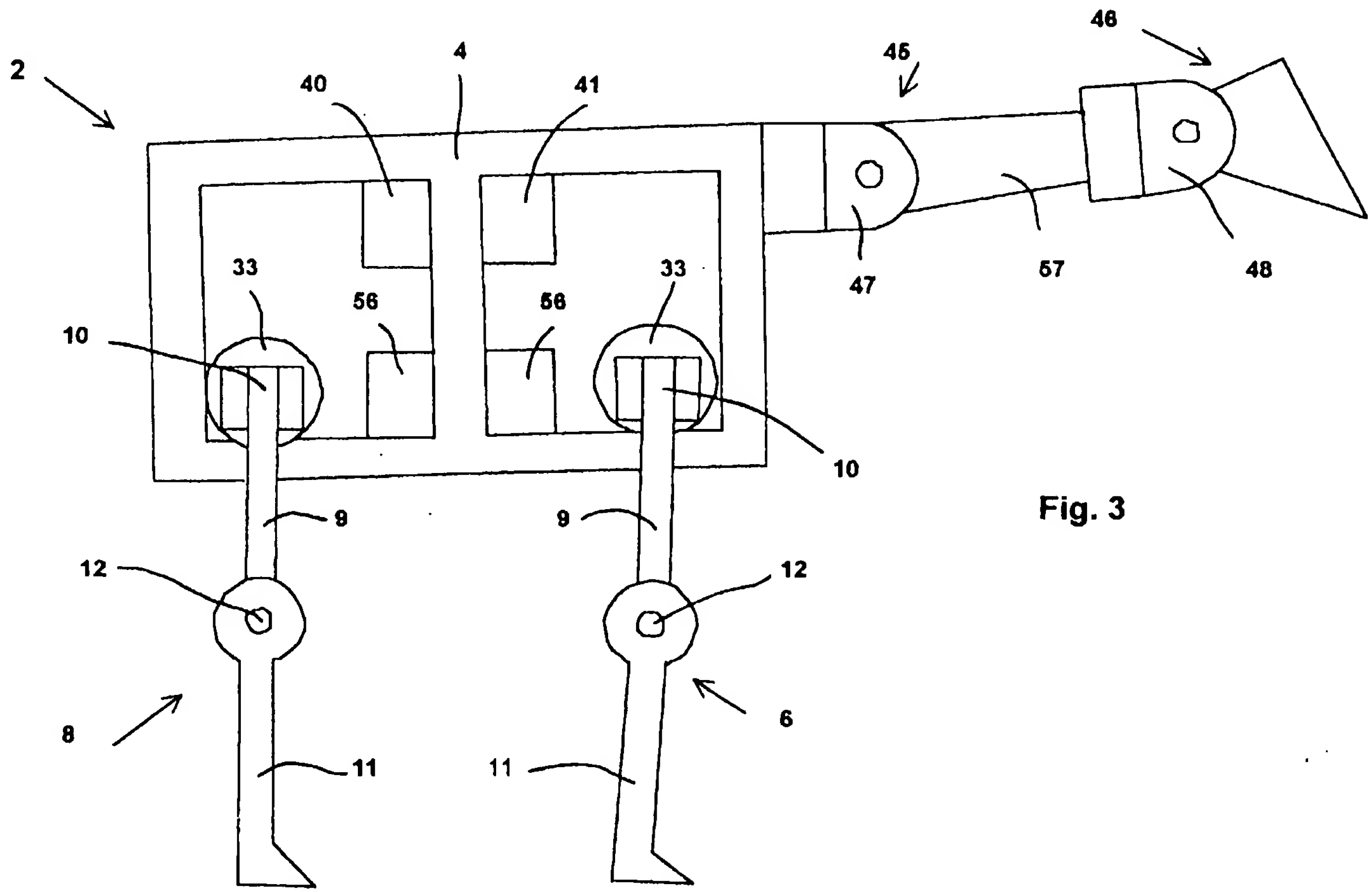

Fig. 3

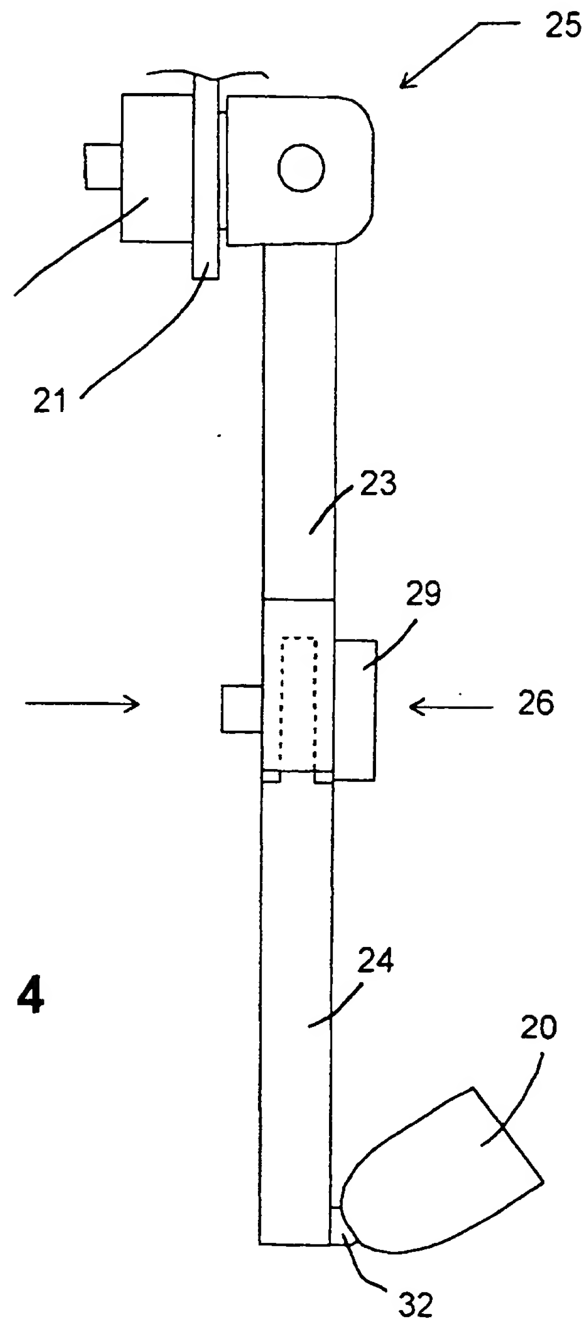

Fig. 4

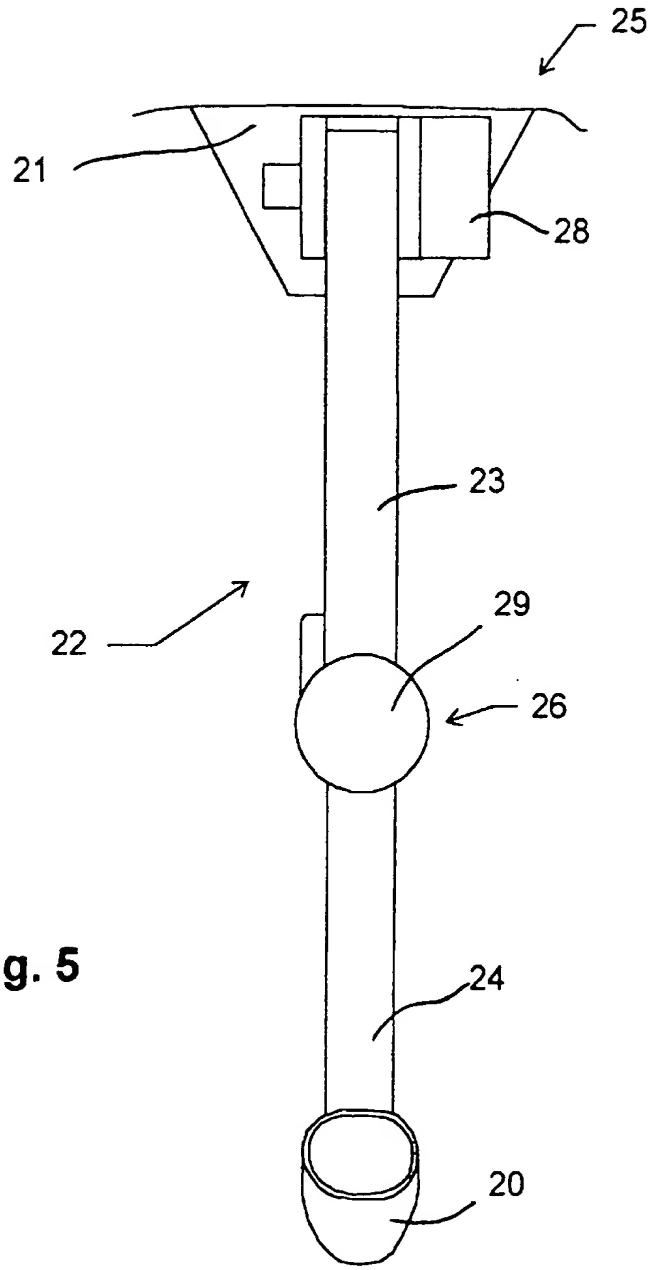

Fig. 5

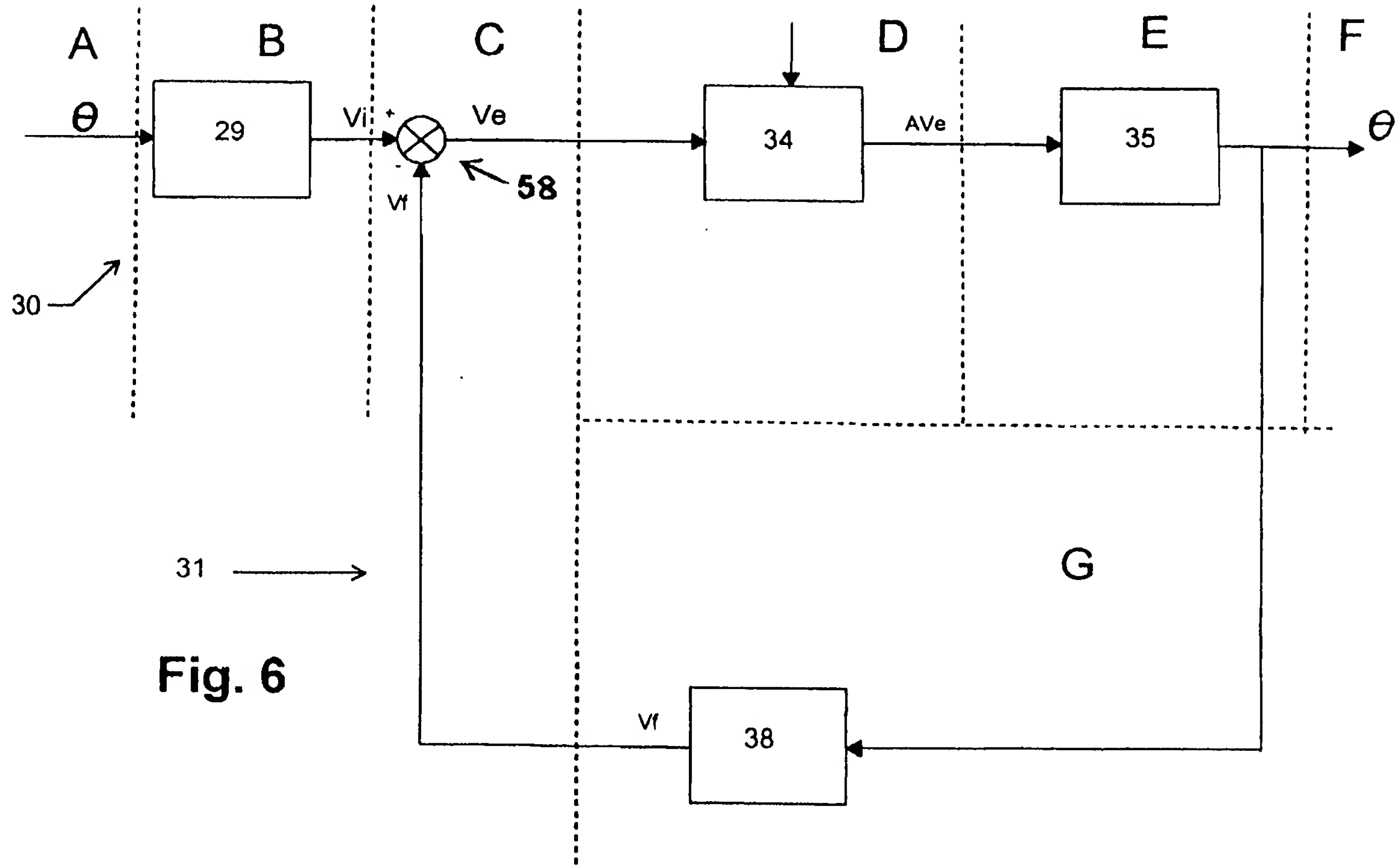

Fig. 6

Fig. 7

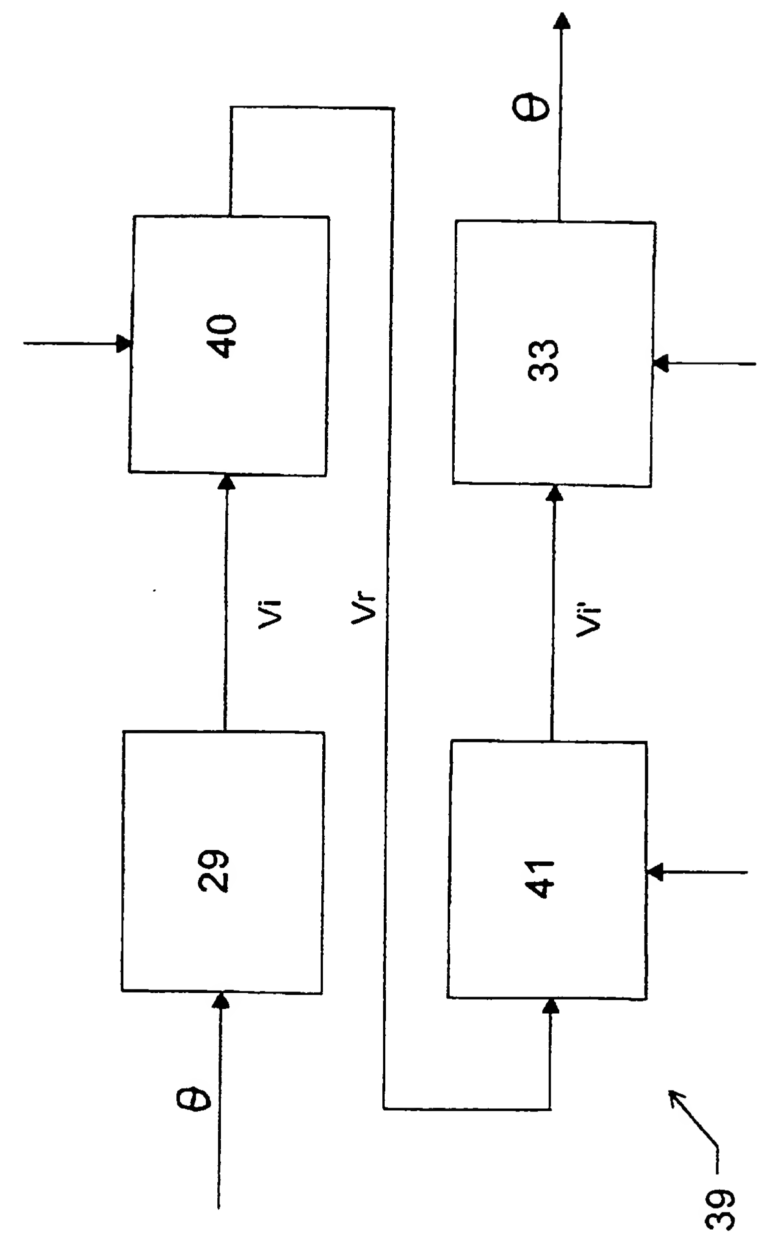

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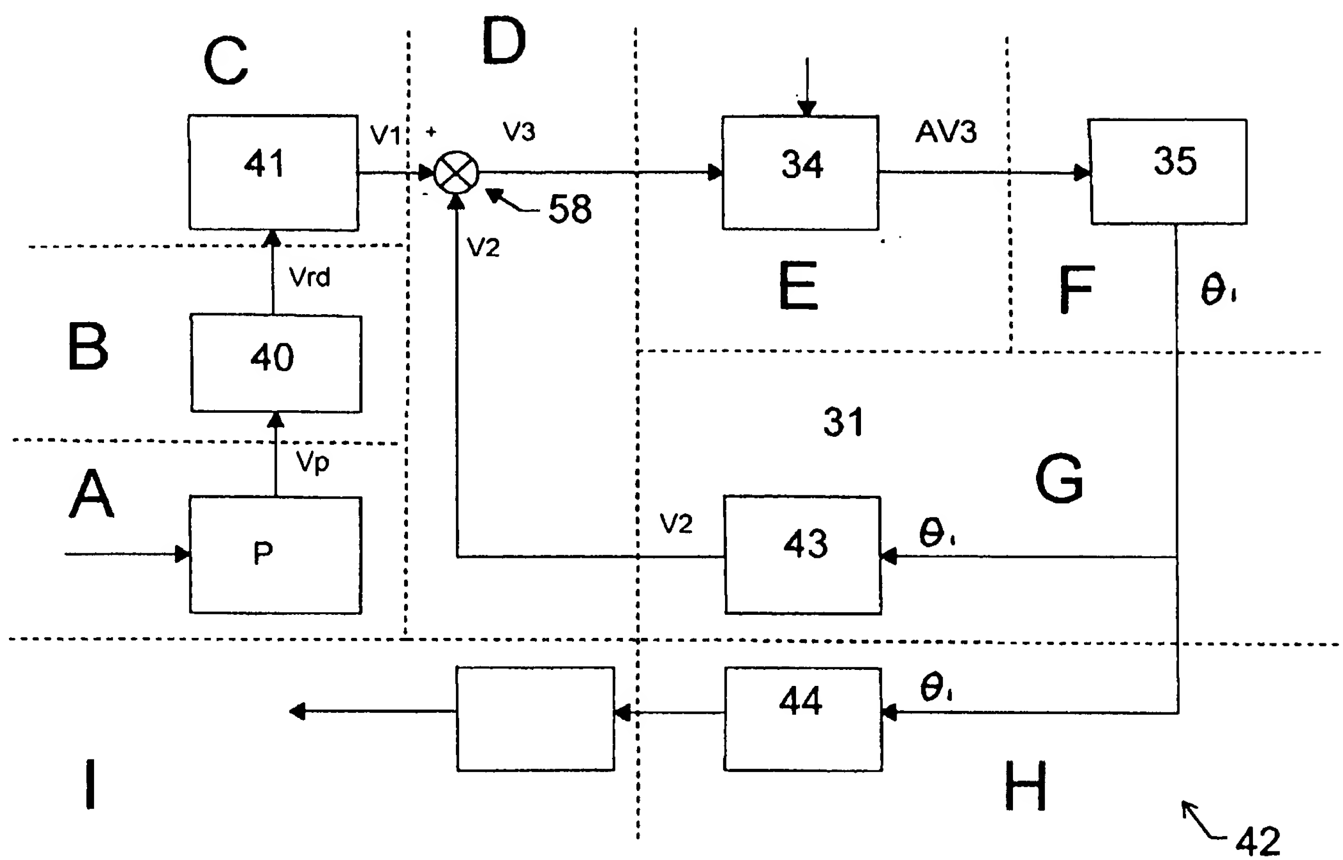
Fig. 8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41
V1
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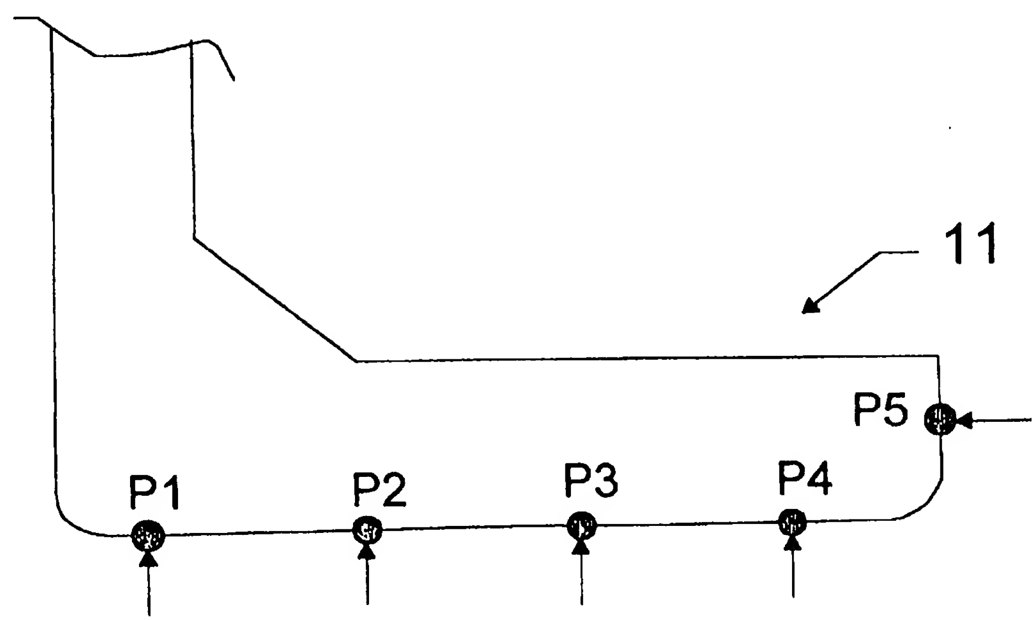
Fig. 9



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REMOTELY CONTROLLED ROBOTIC TOY

Field of this Invention

THIS INVENTION RELATES TO A ROBOTIC TOY WHICH IS REMOTELY CONTROLLED TO PERFORM ACTIONS.

Background to this Invention

Much prior art exists covering models of remotely-controlled planes, kites, trains, boats and other types of machines. Records of mechanical people and animals go back more than 2,000 years. The title of 'robot' means any machine that can be programmed to do work. The most common type of robot is the mechanical arm, fixed to the floor or work-bench. Since the advent of computers, the field of robots has proliferated and computer-controlled vehicles, space-craft and deep-sea exploration are now commonplace.

In the field of toys, the development of remotely-controlled robotic actions for animals and replicas of humans has been less dramatic - until now. According to the embodiment of this invention, there is provided a remotely-controlled robotic toy animal having legs, which can be controlled to propel the toy forward, backward or in any other direction. The concept comprises a master control unit which is held in a support stand and finger-manipulated.

While the embodiment of this invention relates initially to the remotely-controlled robotic actions of a toy, the concept can be applied to legged vehicles for traverse over difficult terrain which is unsuitable for wheeled or tracked vehicles.

Similarly, such a remotely-controlled legged robotic vehicle could have application in surveillance operations, filming projects, bomb disposal and other necessities.

According to the principal aspect of this embodiment, there is provided a remotely-controlled, mechanically legged model robot which can move at varying speeds over rugged terrain and comprises:

> a body section with a plurality of mechanical legs connected thereto, each of which can be remotely-controlled to perform specific movements from a master control unit.

The master control unit comprises a plurality of multi-jointed joy-sticks which are each capable of initiating movement in the plurality of mechanical legs fitted to the remotely-operable robotic toy. The embodiment of this invention therefore comprises a plurality of leg sections, preferably four, but could in another embodiment be to any number and comprise a leg section, a hip joint, a thigh portion, a knee joint and a shin/foot portion.

In the example given, there are four leg sections. Each leg section comprises a hip joint, a thigh portion, a knee joint, and a shin/foot portion (other examples could have other configurations, for instance, to include an ankle joint and separate foot and shin portions); and the control means being such that it comprises first master-slave control means for the first leg section and second master-slave control means for the second leg section and so on for the third and fourth leg sections also, with the first, second, third and fourth master-slave control means each being such that it is movable by a finger or thumb of a user, and with the first, second, third and fourth control means each being such that its movements cause similar movements to be effected by its leg section, whereby the user is able to control the operation of the first, second, third and fourth leg sections by movements made by the user to the respective first, second, third, and fourth master-slave control means. The apparatus of the present invention is thus able to be used such that the fingers of the user are able to control the movements of the leg sections. This finger/thumb control of the apparatus of the invention enables the remotely-controlled robotic toy to

walk in a natural-seeming and spontaneous fashion approximately in the manner of living quadrupeds.

Preferably, the apparatus is one in which the first, second, third, and fourth master-slave control means each comprise a multi-jointed joystick (hereon after referred to as "joystick") having a first portion for moving the thigh portion of the model, and a second portion for moving the shin/foot portion of the robotic toy.

Preferably, the joysticks are each in approximately the same shape as the first, second, third and fourth leg sections, whereby the user is able to move a chosen part of the leg sections simply by moving the respective part on the joystick. This may be done directly or indirectly; i.e., the user could move the chosen part itself by gripping it and manipulating it or the user could effect movement of the chosen part by gripping and manipulating the shin/foot portion. The shin/foot portion may include means by which the user's finger or thumb can connect to the shin/foot portion. This could, be achieved by using a thimble-type of attachment or by other means. These could be flexibly secured to the shin/foot portions.

The first, second, third and fourth master-slave control means may be other than joysticks if required so that there may be, for example, any suitable and appropriate transducer arrangements. Generally, the first, second, third, and fourth master-slave control means can each be of any design that operates such that an input to it by a finger or thumb of the person using the apparatus of the invention is output as a movement desired by the user, in the leg sections. One advantage of using joysticks in the shape of the leg sections is that a chosen movement of a joystick is mirrored by its respective leg section, thus providing a very simple and easyway for a person using the apparatus to control the movements of the robotic toy. Another advantage of using the joysticks is that it is thereby possible to control a system that has multiple degrees of freedom of movement. The present example of this embodiment of the invention would have, in the leg sections, twelve degrees of freedom of

movement; two for each hip joint, and one for each knee joint. Normally this would require either sophisticated software to provide automatic control means or a team of people who each control two degrees of freedom and attempt to coordinate their actions. The disadvantages of the first system is the cost of the software and that the user would not have direct and spontaneous control of the movements of each leg but instead could only make strategic decisions such as which direction to take, how fast etc. The disadvantages of the second system are that one user is not in control and that co-ordination of several users is difficult. The use of multi-jointed joysticks and master-slave control ensures that the user has spontaneous, direct control of the movements of the legs of the robotic toy.

The apparatus may be such that the first, second, third and fourth master-slave control means each comprises one position control system for each degree of freedom of movement in each joint; and the position control systems may incorporate negative-feedback control loops. A position control system with a negative feedback control loop may give precision and smoothness of movement of the leg sections.

The apparatus of the invention may include actuators for moving the thigh and shin/foot portions of the leg sections. Usually there will be one of the actuators for each degree of freedom of movement permitted by one of the portions of the leg sections.

The actuators may be pnuematic, electric, hydraulic or may be some other kind of actuator.

There could be, located on the joints of the leg sections, position transducers. There would be one position transducer for each degree of freedom of movement of each joint. For instance, there would be two at the hip joints if these were to be universal joints which have two degrees of freedom of movement but three if ball-joints were used which have three degrees of freedom of movement. Similar position transducers could be located on the joints of the joysticks. Again one transducer would be used for each degree of freedom. Consequently, each transducer on each joystick would have a counterpart on the

respective leg section. A transducer on the joint of a joystick would thus provide the input signal to a negative-feedback control loop of the appropriate position control system; and the transducer on the joint of the corresponding leg section would provide the feedback signal for the negative-feedback loop. The difference between the two signals (input and feedback) would be the error signal which would control the extension or contraction of the appropriate actuator. For a pnuematic or hydraulic actuator this could be achieved using a proportional valve; for an electric actuator, for instance, a servo-motor, the error signal would be amplified to provide the necessary power.

The console could incorporate a transmitting device. This could be a radio transmitter or other kind of transmitter. The transmitter would transmit the signals from the transducers on the joysticks to a receiver on the body section of the robotic toy. The receiver would receive the broadcast radio (or other) signal from the transmitter and then modify it and send the modified signal to the intended position-control system as the input signal. In this way the robotic toy could be remotely controlled. Other means of remote control are also feasible. The console could also be connected to the robotic toy by a so-called umbilical cord which would enclose flexible electrical wire that would conduct the signals from the transducers on the joysticks to their respective position-control systems.

The robotic toy would require a power source. This could be in the form of a battery or compressed gas, for electrically or pnuematically operated actuators respectively. Other power sources may also be used such as fuel cells or internal or external combustion engines. The power source could be located on the body section of the robotic toy or it coulld be towed in a small trailer. In fact other components of the robotic toy could be carried in such a towed trailor such as the receiver, thereby reducing the load borne by the robotic toy.

The apparatus of the invention may also include a force-feedback arrangement enabling a force encountered by the first, second, third or fourth leg sections to be felt by the

respective fingers and thumbs of the user via the joysticks. Thus the user may be able to feel through their fingers and/or thumbs when the leg sections have encountered an obstacle. Without such feel, a leg could snag on an obstacle and the tendency would then be for the user to apply more force to that leg section via the master-slave control means in order to try and get the leg section to move and an imbalance or other problem might ensue, which is desirably avoided.

The force-feedback system may include force transducers in or on the leg sections. The force transducers may be, for example, in the shin/foot portions of the leg sections.

The force transducers could send appropriate signals via other control systems to apply a braking force at the appropriate joint or joints of each joystick in order to create in the fingers/thumbs of the user, the approximate impression of encountering a resistance to movement akin to that experienced by the robotic toy when striking an obstacle. The braking force applied to the joints of the joysticks could be proportional to the signal sent by the transducers on the shin/foot portions of the joysticks. The signal would first be transmitted by a transmitter located on the robotic toy to a receiver on the control console. The receiver could then modify and then send the signal to a position control system that would control the position of an actuator such that the actuator would extend or contract precisely in proportion to the signal sent by the transducer on the shin/foot section of the leg in question. The actuator could compress a spring and the spring could apply the braking force to the joint or joints on the joystick in question. The magnitude of the braking force would depend on the degree of compression of the spring which would be proportional to the signal from the transducer. The position control system could incorporate a negative-feedback control loop.

The robotic toy could also have a head section with a mouth portion and a neck section. These could also be remotely controlled by position control systems incorporating

negative-feedback control loops similar to those described for the control of the leg sections and the force-feedback systems. In this way life-like movements of the neck and head could be achieved. Alternatively, remotely controlled switches could enable simpler movements to be made such as biting or butting for instance by releasing compressed springs to propel the head and neck sections forward and a mechanism could work to provide a biting action by the mouth portion as this happened. This type of system would not require master-slave control. Means could be incorporated to enable the spring to be compressed again so that the action could be repeated.

An embodiment of the invention will now be described solely by way of example and with reference to the accompanying drawings in which:

Figure 1 is a perspective, schematic view of the apparatus showing the user operating it, in this the support frame of the remote-control console, the left hand of the user and the head and neck sections of the remotely-controlled robotic toy are not shown for clarity of illustration;

Figure 2 is a side view of the remote-control console shown in Figure 1, showing schematically two joysticks;

Figure 3 is a schematic side view of the remotely controlled robotic toy shown in Figure 1;

Figure 4 is a front view of a joystick shown in Figure 1, forming part of a master-slave control means, a force-feedback system being ommitted for ease of illustration;

Figure 5 is a side view of a joystick shown in Figure 4;

Figure 6 shows the layout of a position control system incorporating a negative feedback control loop, forming part of the master-slave control means;

Figure 7 shows a block diagram showing how the control of one degree of freedom of one joint would be achieved from the input to the respective master-slave system, via a remote-control radio system, to the desired output in the corresponding robotic toy leg section;

Figure 8 shows a force-feedback arrangement forming part of the apparatus of the invention;
Figure 9 shows schematically part of a shin/foot portion of a leg section forming part of the apparatus of the invention.

Referring to figure 1, there is shown apparatus 1: a remotely-controlled robotic toy 2 and the remote-control means 3. The remotely-controlled robotic toy(from hereon referred to as "robotic toy") 2 comprises a body section 4, first leg section 5, second leg section 6, third leg section 7, and fourth leg section 8. Each leg section 5, 6, 7, 8, comprises a thigh portion 9, a hip joint 10, a shin/foot portion 11, and a knee joint 12.

The remote-control means 3 is such that it comprises first master-slave control means 13 for the first leg section 5, second master-slave control means 14 for the second leg section 6, third master-slave control means 15 for the third leg section 7, and fourth master-slave control means 16 for the fourth leg section 8. The first, second, third and fourth master-slave control means 13,14,15,16 are connected to a console 21. The console 21 comprises a body section 53 (see Figure 2) and a support frame 54. The first, second, third and fourth master-slave control means 13,14,15,16 are each such that they are movable by a finger 18 or thumb 19 of the user 17, as is shown somewhat schematically in figure 1. The first, second, third and fourth master-slave control means 13,14,15,16 are also each such that its movements cause similar movements to be effected by its leg section 5,6,7,8. Thus the user 17 is able to control the operation of the first, second, third and fourth leg sections 5,6,7,8 by movements made by the person 17 with their fingers 18 and/or thumbs 19 to the respective first, second, third and fourth master-slave control means 13,14,15,16. The fingers 18 and thumbs 19 of the user 17 connect with the first, second, third and fourth master-slave means 13,14,15,16 by means of sockets 20. The sockets 20 may be flexibly connected to the first, second, third and fourth master-slave control means 13,14,15,16 preferably at the shin/foot portion 11.

The second master-slave control means 14 is shown in more detail in figures 2, 4 and 5. The first, third, and fourth master-slave control means 13,15,16 are the same as the second master-slave control means 14. The second master-slave control means 14 comprises a console 21. The first, third and fourth master-slave control means 13,15,16 may share the same console 21. The console 21 contains four multi-jointed joysticks (hereafter referred to as "joysticks") 22. The joystick 22 is an approximately scaled version of the second leg section 6. Thus the joystick 22 has a first portion 23 which is similar to the thigh portion 9, a second portion 24 which is similar to the shin/foot portion 11, and a socket 20 which is secured using a flexible connector 32 (see Figure 4) to the second portion 24 and into which the user's 17 finger 18 is inserted. As can be seen from figures 2, 4 and 5, the joystick 22 also comprises a first joint 25 which is similar to the hip joint 10, and a second joint 26 which is similar to the knee joint 12. Because the joystick 22 is of the same general shape as the second leg section 6, it is very easy for the user 17 to move the second portion 24 via the socket 20 and thereby also to move the whole joystick 22 and to get a "mirrored" movement in the appropriate portion of the second leg section 6.

Figures 4 and 5 show how the joystick 22 has two position transducers 27, 28, for each universal hip joint 25 and one position transducer 29 for each knee joint 26. Each leg section 13, 14, 15, 16 also has position transducers at the hip 36, 37 and at the knee 38. These position transducers 27, 28, 29, 36, 37, 38 (hip transducers 36, 37 are ommitted from the drawings for ease of illustration) are used in separate position control systems 30, which each incorporate a negative-feedback control loop 31. The position control systems 30 are shown in Figure 6. In this way the movements of these joints on the joystick 22 can be translated into electrical signals and sent to the correct position control system which controls the corresponding actuator and thus also the corresponding leg section.

Figure 3 is a schematic drawing of the robotic toy 2 in which only the second and fourth of the leg sections 6, 8 are visible. Figure 3 shows how the first, second, third and fourth leg sections 5, 6, 7, 8 include actuators in the form of electric servo-motors 33 for moving the

sections 5, 6, 7, 8 include actuators in the form of electric servo-motors 33 for moving the thigh and shin/foot portions 9, 11 of the first, second, third and fourth leg sections 5, 6, 7, 8. There are two electric servo motors 33 (only one is shown for ease of illustration) for each hip joint 10 which are universal joints with two degrees of freedom of movement. The two electric servo motors enable the thigh portion 9 to move in two planes. The knee joint 12 has only one electric servo motor 33 (not shown for ease of illustration) and only one degree of freedom of movement. It should be noted that with electric servo motors 33 the negative-feedback control loop 31 is typically an integral part i.e., the electric servo motors 33 contain a position transducer for the feedback signal and the electrical circuitry to produce an error signal. In the case of electric servo motors 33 there would be no need for position transducers 36, 37, 38 to be located on the first, second, third or fourth leg sections 5, 6, 7, 8 of the robotic toy 2 because the electric servo motor 33 used for each of the leg sections 5, 6, 7, 8 would have an integral position transducer for the purpose of providing feedback in the negative-feedback control loops 31.

Figure 6 shows how the relative movement between the thigh portions 9 and the shin/foot portions 11 of the leg sections 5, 6, 7, 8 can be achieved. For this purpose Figure 6 has been divided up into sections labelled A to G. Each section is explained below.

A. The person 17 moves their finger 18 or thumb 19 (whichever is inserted into the socket 20) in such a way as to cause the second (shin/foot) portion 24 of the joystick 22 (corresponding to the foot/shin portion 11 of the second leg section 14) to move, relative to the first (thigh) portion 23 of the joystick 22, about the knee joint 26. By this means, an input is made to the apparatus 1.

B. The relative movement is picked up by a position transducer 29, and a signal V_I is sent. The signal V_I is proportional to the magnitude of the angle of the joint. Thus changes in the signal V_I would be proportional to changes in the angle of the joint as would be caused by movements of the first (thigh) and second (shin/foot) parts of the joystick. It should be noted that for ease of illustration the remote-control components are ommitted

and the signal is shown to travel directly from the position transducer to the electronic circuit 58 (for an illustration of the remote-control system 39, see Figure 7).

C. An electronic circuit 58 subtracts the feedback signal V_F from the input signal V_I to produce an error signal V_E.

D. The error signal V_E is amplified by an amplifier 34 to produce an amplified signal AV_E.

E. The amplified signal AV_E is sent to an actuator 35 and comprises the power supply of the actuator 35 . The actuator 35 may be a pnuematic or hydraulic ram device or it may be an electric motor. In the case of a pnuematic or hydraulic ram device, the means of amplification would be through the use of pressurised fluid. In the case of the actuator 35 being an electric motor, the error signal V_E would be amplified by an electrical amplifier and the amplified signal AV_E would be supplied directly to the electric motor. In the case of the actuator 35 being a rotational electric motor, it would rotate in either a forwards or a backwards direction (forwards or backwards meaning clockwise or anticlockwise, depending on convention used, but 'forwards' meaning that the actuator would cause the second section 11 of the second leg portion 6 to rotate in the same direction as the corresponding shin/foot portion 11 of the joystick 22) according to the sign of the error signal V_E (positive or negative). The actuator 35, in the form of a rotational electric motor would also rotate forwards or backwards by an amount proportional to the magnitude of the error signal V_E. The forwards or backwards rotation is denoted by θ. The power sources, for instance batteries 56 could be stored on the body 4 of the robotic toy 2, and on the body 53 of the remote-control console 21.

F. The actuator 35 causes relative movement between the first (thigh) portion 9 and the second (shin/foot) portion 11 of the second leg section 6 of the robotic toy 2. This is an output and it corresponds in magnitude and direction to the input movement between the thigh portion 9 and the shin/foot portion of the joystick 22 of the second master-slave control means 14.

G. The output relative movement is picked up by a position transducer 38 located on the knee of the second leg section 6, of the robotic toy 2. The position transducer 38 sends a feedback signal V_F to the electronic circuit 58 mentioned at Section C above.

The position control system 30 shown in Figure 6 operates to achieve a balance between the position transducers 29 and 38. This is achieved when $V_I - V_F = 0$, i.e., when $V_E = 0$ and the actuator is not moved. In this way, movements of the joysticks 22 and their respective first, second, third and fourth leg sections 5, 6, 7, 8 are synchronised.

Each of the actuators has one of the position control systems 30.

The balancing action of the position control system 30, as shown in Figure 6 is rapid such that the movement of the actuator 33 appears to the user 17 to be smooth and continuous.

Referring now to Figure 7, there is shown a block circuit diagram of a remote-control system 39 for relating control signals from the remote-control means 3 to the robotic toy 2. In this case the Figure is not as complex as Figure 6 and so has not been similarly divided in to labelled sections. As in Figure 6, the user 17 moves their finger 18 or thumb 19 (whichever is inserted into the socket 20) in such a way as to cause the second (shin/foot) portion 24 of the joystick 22 (corresponding to the foot/shin portion 11 of the second leg section14) to move, relative to the first (thigh) portion 23 of the joystick 22, about the knee joint 26. By this means, an input is made to the apparatus 1. The relative movement is picked up by a position transducer 29, and a signal V_I is sent. The signal V_I is proportional to the magnitude of the angle of the joint. Thus changes in the signal V_I would be proportional to changes in the angle of the joint as would be caused by movements of the first (thigh) and second (shin/foot) parts of the joystick. The signal is converted to and transmitted as a radio signal V_R by a transmitter 40. The transmitted signal V_R is received by a receiver 41. It should be noted that one transmitter 40 and one receiver 41 may be used for the control system of each degree of freedom of movement of the leg sections 5, 6,

7, 8, or one or several transmitters 40 with several radio channels and one or several receivers 41 with several radio channels may be used. The receiver 41 would convert the radio signal V_R back to the original input signal V_I (or to a similar or proportional signal) and is denoted as $V_{I'}$ and this would be sent to the actuator, which in this case is an electric servo motor 33. The electric servo motor 33 contains the means to amplify the input signal $V_{I'}$, an integral position transducer, and a position control system 30 incorporating a negative-feedback control loop 31. The output of the system 39 is an angular displacement θ, between the thigh portion 9 and the shin/foot portion 11 of the second leg section 6. This dispacement θ would correspond to the input displacement.

The control of each degree of freedom of movement of each leg section 5, 6, 7, 8 would be achieved using similar remote-control systems.

In this way, the user 17 would be able to control the movements of the robotic toy 2 by manipulating the master-slave control means of the remote-control means 3.

Referring now to Figure 8, there is shown a force feedback arrangement 42. The force feedback arrangement 42 is for ease of control of the first, second, third and fourth leg sections 5, 6, 7, 8. More specifically, the force feedback arrangement 42 enables forces encountered by the first, second, third and fourth leg sections 5, 6, 7, 8, for example at the shin/foot portions 11, to be conveyed back to the fingers 18 or thumbs 19 of the user 17 via the joystick 22. Figure 8 is specific to forces from the shin/foot portions 11 but forces from other parts of the leg sections 5, 6, 7, 8 can similarly be transferred back and they have not been described in Figure 8 to avoid undue complication. The foot portion 11 of the first, second, third and fourth leg sections 5, 6, 7, 8 might need the force feedback if the shin/foot portion 11 were snagged upon an obstacle such as for example a fallen branch. Without the force feedback, the apparatus 1 might feel clumsy and numb to the user 17 and the user 17 might be unaware of any obstacles that had been collided with. The force

feedback system 42 would also provide the user 17 with information about when each leg section 5, 6, 7, 8 was in contact with the ground surface, or above this and being lifted.

Figure 8 shows how the forces on the sole of the shin/foot portion 11 of the second leg section 6 are fed back to the fingers of the user 17. Figure 7 has been divided up into sections A to I, and incorporates a separate remote-control means to that described in Figure 7. Sections A to I are described herinbelow.

A. An input to the force-feedback arrangement 42 is achieved by pressure on the shin/foot portion 11. For simplicity these different pressures can be treated as isolated forces acting perpendicularly to the sole of the shin/foot portion 11. It is these forces which are fed back to the joystick 22. The actual force fed back is a single force which is representative of all the forces. The signal sent by the transducer or transducers is denoted V_P.

B & C The signal V_P is converted to and transmitted as a radio signal V_{Rd} by a transmitter 40 located on the body section 4 of the robotic toy 2. The transmitted signal V_{Rd} is received by a receiver 41. It should be noted that one transmitter 40 and one receiver 41 may be used for the force-feedback system 42 of each of the leg sections 5, 6, 7, 8, or one or several transmitters 40 with several radio channels and one or several receivers 41 with several radio channels may be used. The receiver 41 would convert the radio signal V_{Rd} back to the original input signal V_P (or to a similar or proportional signal) and is denoted as V_1. The signal V_1 comprises the input signal to a negative-feedback control loop 31.

D. An electronic circuit 58 subtracts the feedback signal V_2 from the input signal V_1 to produce an error signal V_3.

E. The error signal V_3 is amplified by an amplifier 34 to produce an amplified signal AV_3.

F. The amplified signal AV_3 is sent to an actuator 35 and comprises the power supply of the actuator 35 . The actuator 35 may be a pnuematic or hydraulic ram device or it may

be an electric motor. In the case of a pnuematic or hydraulic ram device, the means of amplification would be through the use of pressurised fluid. In the case of the actuator 35 being an electric motor, the error signal V_3 would be amplified by an electrical amplifier and the amplified signal AV_3 would be supplied directly to the electric motor. In the case of the actuator 35 being a rotational electric motor, it would rotate in either a forwards or a backwards direction according to the sign of the error signal V_3 (positive or negative). The actuator 35, in the form of a rotational electric motor would also rotate forwards or backwards by an amount proportional to the magnitude of the error signal V_3. The forwards or backwards rotation is denoted by $\theta 1$.

G. The movement $\theta 1$ of the actuator 35 would be detected by a position transducer 43. This position transducer 43 would output a signal V_2 proportional in magnitude to the movement $\theta 1$. It would be a positive signal if the movement $\theta 1$ was forwards or a negative signal if the movement $\theta 1$ was backwards. The signal V_2 from the position transducer would constitute the feedback signal for the negative feedback loop 31.

H. The movement $\theta 1$ also compresses or relaxes a spring 44. The spring 44 may be a coil spring or an air spring or any other kind of spring. The spring 44 would compress if the movement $\theta 1$ was forwards or extend if it was backwards.

I. The compressed spring 44 exerts a force which operates brakes on all or some of the joints of the relevant joystick 22. This would be felt as a resistance to movement in the joints of the joystick 22. This would be felt by the finger 18 or thumb 19 of the user 17 and corresponds in magnitude to the forces acting on the shin/foot portion 11 of the second leg section 6.

Referring now to Figure 9, there is shown a schematic representation of part of the shin/foot portion 11. The shin/foot portion 11 has transducers P_1, P_2, P_3, P_4 and P_5 producing signals V_{P1}, V_{P2}, V_{P3}, V_{P4} and V_{P5} respectively. These signals are proportional to the pressure exerted upon the transducers P_1, P_2, P_3, P_4 and P_5.

The transducers P_1 - P_5 are for the detection of weight and exertion, that is the load borne by the shin/foot portion 11. The transducer P_5 is for detecting collisions with obstacles.

The input to the force-feedback arrangement 42 shown in Figure 8 is V_P. This is a summation of all the outputs of the transducers V_{P1} to V_{P5}, that is $V_P = V_{P1} + V_{P2} + V_{P3} + V_{P4} + V_{P5}$.

Most of the time, the output of transducer V_{P5} will be zero as the shin/foot portion 11 will not be engaging obstacles.

The distribution of the transducers P_1 - P_4 over the sole of the shin/foot portion 11 should be such as to ensure that V_P remains constant for a constant load upon the foot portion 11. In other words, if a given load were to be evenly distributed over the sole of the shin/foot portion 11, each transducer P_1 to P_4 might output, for example, 10 mV (millivolts). Thus $V_P = V_{P1} + V_{P2} + V_{P3} + V_{P4} = 40$ mV ($V_5 = 0$). If then the ground became uneven, it might happen that the same load would then be borne by only part of the shin/foot portion 11, for example the part where transducer P_2 is located. In this case V_1, V_3 and $V_4 = 0$ and $V_5 = 0$. V_2 would be expected to be close to 40 mV. Thus V_P would remain constant for a constant load upon the foot portion 11. The more transducers used, then the more accurately is V_P able to represent the total load on the sole of the shin/foot portion 11.

The output from the transducer P_5 is larger than the outputs from other transducers P_1 - P_4, i.e., it would be more sensitive. The outputs from the other transducers P_1 to P_4 are used to restrict the movement of the joystick 22 and thus to simulate forces felt upon the shin/foot portion 11 of the leg sections 5, 6, 7, 8. These forces are forces of weight and exertion. However, the larger output from the transducer P_5 is used to virtually halt the joystick 22, as indeed a collision with an obstacle would tend to halt the movement of the leg sections 5, 6, 7, 8 and thus the robotic toy 2.

It can be seen in Figure 3 that the robotic toy 2 has a neck section 45 and a head section 46. The neck section 45 comprises a first universal joint 47 which connects the neck section 45 to the body section 4 of the robotic toy 2; and a second universal joint 48 which connects the head section 46 to the neck section 45. The neck section 46 also comprises a neck portion 56. The head and neck sections 45, 46 could be moved by actuators 35 (not shown in Figure 3 for ease of illustration) for instance electrical servo motors 33.

It can be seen from Figure 2 that the remote-control means 3 has a neck section 49 and a head section 50. The neck section 49 comprises a first universal joint 51 which connects the neck section 49 to the console 21 of the remote-control means 3; and a second universal joint 52 which connects the head section 50 to the neck section 49. The neck section 49 also comprises a neck portion 55.

The neck section 45 and head section 46 of the robotic toy are controlled by remote-control master slave means in a simliar way to the leg sections 5, 6, 7, 8. In this case the head and neck sections 49, 50 of the remote-control means 3 comprise the "master" and the head and neck sections 45, 46 of the robotic toy comprise the "slave". The control system 39 as shown in Figure 7 is also appropriate in this case and for a description of this see above.

The head and neck sections 45, 46 of the robotic toy 2 could thus be controlled by the user 17. The user would manipulate the master (head and neck sections 49, 50 of the master-slave means) and howsoever this is moved, the slave (head and neck sections 45, 46 of the robotic toy) would move in a synchronised fashion. In order to manipulate the head and neck sections 49,50 of the master-slave means, the user would need to momentarily remove one finger 18 and/or thumb 19 from a socket 20 in order to use that hand.

It is to be appreciated that the embodiment of the invention described above with reference to the accompanying drawings has been given by way of example only and that modifications may be effected. Thus, for example, actuators 35 other than electrical servo motors 33 may be employed; the head and neck sections 45, 46, 49, 50 could be of several types reflecting the different kinds of heads and necks in the animal kingdom and the differing ways that such are moved; and may be controlled by means other than master-slave control; the head section 46 could include powered mouth parts; there might be more or less than four leg sections 5, 6, 7, 8; some leg sections 5, 6, 7, 8 could be replaced with wheels to allow fewer legs to be required but without sacrificing mobility or stability; a force-feedback system 42 may or may not be used; and a power source other than an electrical one might be used e.g., hydraulics or pnuematics etc; the console 21 might alternatively be suspended from straps secured around the neck of the user 17, rather than rest on a support stand 54; instead of using an electrical feedback signal, mechanical feedback could be employed for the position control system 30 or alternatively, non-feedback control systems could be employed so that the control of the movements of the leg sections could be achieved by observing their position and direction and modifying these by supplying power to the actuators manually via valves or switches on the joysticks; ball and socket joints could be used for the hip joints 10, 25 rather than universal joints; it is possible that other parts of the user's 17 body could be used in the control of the apparatus 1, for instance, the feet could be used to depress switches to control the movements of the head/neck and mouth parts of the robotic toy 2. It was mentioned that instead of transmitting a signal from the remote-control means 3, an "umbilical" connection could be used containing flexible electric wires to permit the signals from the transducers 27, 28, 29 on the joysticks 22 being delivered to the robotic toy 2. If such an umbilical connection were used, then it could be possible to dispense with an electrical system and use for example, an hydraulic servo system. Other modifications are also possible.

CLAIMS

1. Apparatus for recreational and other uses, which apparatus comprises a model robot, and remote control means for controlling the operation of the model robot : the model robot being such that it comprises a body section and first, second, third and fourth leg sections, with each leg section comprising a thigh portion, a hip joint, a shin-foot portion and a knee joint ; and the control means being such that it comprises first master-slave control means for the first leg section, second master-slave control means for the second leg section, third master-slave control means for the third leg section and fourth master-slave control means for the fourth leg section, with the first, second, third and fourth master-slave control means each being such that its movements cause similar movements to be effected by its leg section, whereby the operator is able to control the operation of the first, second, third and foutrth leg sections by movements made by the person to the respective first , second, third and fourth master-slave control means.

2. Apparatus according to claim 1 in which the first, second, third and fourth master-slave control means each comprise a joystick having a first portion for moving the thigh portion of the model robot, and a second portion for moving the shin-foot portion of the model robot.

3. Apparatus according to claim 2 in which the joysticks are each in the same shape as the first and the second leg sections, whereby the person is able to move a chosen part of the leg sections simply by moving the same shaped part on the joystick.

4. Apparatus according to any one of the preceding claims in which the first, second, third and fourth master-slave control means each comprise a negative-feedback control system for each type of movement in each joint.

5. Apparatus according to any one of the preceding claims and including a force feedback arrangement enabling a force encountered by the first, second, third and fourth leg sections to be felt by a hand of the person on the master-slave control means.

6. Apparatus according to claim 5 in which the force-feedback arrangement includes force transducers in the leg sections.

7. Apparatus according to claim 6 in which the force transducers are in the shin-foot portions of the leg sections.

8. Apparatus according to claim 6 or 7 in which the force transducers are such that they send appropriate signals via another negative feedback control system to apply a braking force at the appropriate joint or joints of each joystick in order to create at the fingers of the user the impression of resistance to movement or of encountering an obstacle.

9. Apparatus according to any of the preceding claims and including actuators for moving the thigh and shin-foot portions of the leg sections.

10. Apparatus according to claim 9 in which the actuators are pnuematically, hydraulically or electrically operated actuators.

11. Apparatus according to any one of the preceding claims in which more or less than four leg sections are used.

12. Apparatus according to claim 11 in which more or less than four master-slave control means are used but corresponding to an equal number of leg sections.

13. Apparatus according any one of the preceding claims in which any of the leg sections are replaced with wheels.

14. Apparatus according to any one of the preceding claims and including neck and head sections, and control means for controlling the operation of the head and neck sections: the head section being such that it comprises a head portion and a mouth portion and a mouth joint and the neck section being such that it comprises a neck portion with two neck joints; and the control means being such that it controls a master-slave control means such that it is moveable by a hand of the user and that its movements cause similar movements to be effected in the neck and head sections, whereby the person is able to control the operation of the head and neck sections by movements made by the person to the respective master-slave control means.

15. Apparatus according to claim 14 in which the head and neck sections are controlled by means other than master-slave control means.

17. Apparatus according to any of the preceding claims in which the master slave control means for the head and neck sections each comprise a negative feed back control system or systems for the movement of each joint.

18. Apparatus according to claim 15 in which the control means for the head and neck sections are simple switches.

19. Apparatus according to any of the preceding claims in which the control means for the head and neck sections are of the same shape as the head and neck sections.

20. Apparatus according to any one of the preceding claims and including actuators for moving the head and neck sections.

21. Apparatus according claim 20 in which the actuators are pnuematically, hydraulically or electrically operated actuators.

22. Apparatus according to any of the preceding claims and including radio type of remote control means to relay back and forth control signals between the model robot and the joysticks, which remote control means are integral to the negative–feedback control loops employed.

23. Apparatus according to any of the preceding claims and including an umbilical type of connection to relay power and/or control signals back and forth between the model robot and the control means.

24. Apparatus for recreational and other uses, substantially as herein described with reference to the accompanying drawings.

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22

Application No: GB 9800648.9 **Examiner:** John Twin
Claims searched: 1 to 24 **Date of search:** 24 August 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): F2Y (YTB)

Int Cl (Ed.6): B25J 3/00, 3/04, 9/16, 11/00

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 850729 A2	(Honda)	1 at least
X	WO 97/02520 A1	(Ross-Hime)	1 at least
X	WO 95/05269 A1	(Edwards)	1 at least
X	WO 94/01042 A1	(Kramer) - see eg figs. 24,26	1 at least
X	US 5841258	(Honda)	1 at least
X	US 5716352	(Viola)	1 at least
X	US 4046262	(NASA)	1 at least
X	JP 8-216066 A	(Hasegawa) - see eg WPI abstract accession no. 96-438014; Patent Abstracts of Japan vol. 96012	1 at least

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